

THE AMERICAN METEOROLOGICAL JOURNAL.

A MONTHLY REVIEW OF METEOROLOGY.

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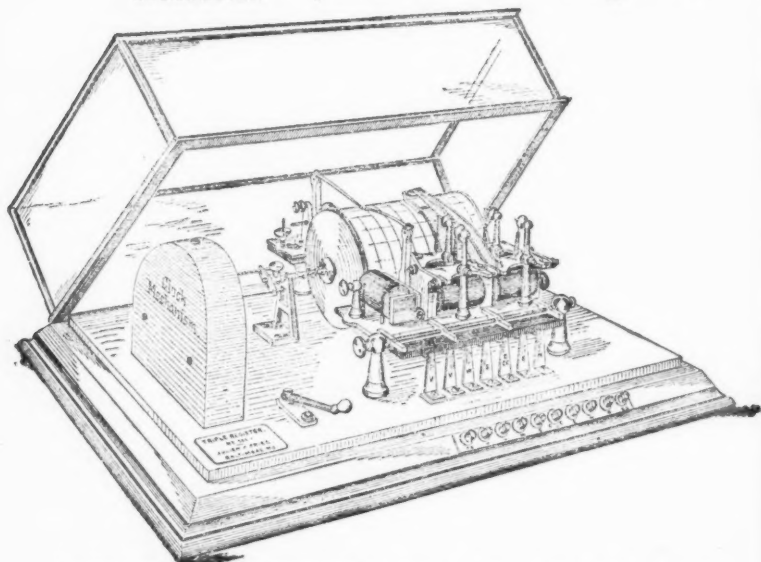
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THE AMERICAN METEOROLOGICAL JOURNAL.

VOL. X.

BOSTON, MASS., APRIL, 1894.

No. 12.

EDITORIAL NOTE.

WITH the close of the tenth volume of the JOURNAL it again becomes our duty to make a few statements regarding the past and future of this publication. In looking back over the year that has just come to a close we cannot help feeling that the JOURNAL has distinctly advanced along the lines which we laid out at the end of the last volume in our editorial note there printed, and we trust that our readers will agree with us. The names of those who have written the original articles that have appeared in the present volume, and the diversity and interest of the subjects that have been treated in these articles, have made the tenth volume of the JOURNAL as valuable a one as any that has preceded it. Indeed, we are persuaded that it has been of more value than any preceding volume to most of our readers, if we may judge by the letters that we have received.

The increasing number of valuable publications that have been sent to us from foreign parts is a welcome sign that the influence of the JOURNAL is growing every day. It has been a great source of satisfaction to us to have so many expressions of approval, not only from our own country but from distinguished meteorologists in other countries, and we take this opportunity of publicly thanking those gentlemen who have so kindly written us their opinion of our work.

It has also been a source of encouragement that the New England Meteorological Society has, as already noted in our pages, subscribed to the JOURNAL for all of its members during the present year, thereby signifying its cordial approval of the work that the JOURNAL is doing, and bearing evidence to its value from an educational point of view.

We have had the hope that the various State Weather Services might find it possible to subscribe to the JOURNAL for such of their observers as would be interested in reading it. It is by no means our wish to interfere in any way whatever with the circulation of such of the State Weather Service publications as are now issued at a subscription price. These local bulletins are of much value and deserve the cordial support of all the observers in the States in which they are issued. We have often had occasion to reprint in this JOURNAL articles that have first appeared in these Monthly Bulletins, and have been glad to call attention to their value. On the other hand, the editors of the various State Weather Service Bulletins and Reviews have, on their part, frequently shown their appreciation of and friendly feeling for this JOURNAL by reprinting in their publications articles and notes that have first appeared in our pages. This spirit of friendly co-operation is one of the cheering features in our work. We wish, however, that this JOURNAL could be more widely read by the volunteer observers of the National Weather Bureau and of the various State Weather Services, and we should be glad to make arrangements for a reduced subscription rate if a considerable number of such observers would agree to take the JOURNAL. We should be pleased to correspond with the directors of the State Weather Services, and with the observers, on this subject. In this connection it may be stated that Mr. E. W. McGann, Director of the New Jersey Weather Service, has for some time taken several copies of the JOURNAL, which are sent around among his observers as a slight return for their gratuitous services, and Mr. McGann assures us that the magazine is thoroughly appreciated by those who see it. A similar plan has been found to work admirably in Prussia, where copies of "*Das Wetter*," a popular meteorological journal, are sent to the volunteer observers as a reward for their services.

We wish to call special attention at this time to the Report of the Conference on Geography of the National Educational Association in relation to the teaching of meteorology in the Secondary Schools, a part of which report is reprinted in this number of the JOURNAL. The Committee of Ten was appointed by the National Educational Association and is in the highest degree a representative body. This Committee of Ten, of whom President Charles W. Eliot of Harvard University is Chairman,

named the Conference of Ten which was to report on the teaching of geography, including meteorology, in the secondary schools. This Conference, also, is a thoroughly representative body, composed of teachers of these subjects, of long experience both in schools and colleges, so that their report is one that deserves the most careful and serious consideration. We especially commend that portion of the report which relates to the teaching of meteorology to the attention of the readers of this JOURNAL, as well as of all teachers and of all persons who are in any way interested in teaching. We ourselves believe that the great field in which meteorology is to develop within the next few years in our country is in the schools, and we most heartily agree with all that the Conference recommends on this subject. It is a source of peculiar gratification to us that two members of this Conference on geography are Associate Editors of this JOURNAL, viz., Prof. Mark W. Harrington, Chief of the United States Weather Bureau, and Prof. William M. Davis, of Harvard University. The meteorologists of this country, as well as of other countries, have reason to be glad that the claims of the science of meteorology have been so ably presented by two gentlemen so well fitted for the task as Prof. Harrington and Prof. Davis.

In our former editorial note, at the close of our last volume, we gave a list of the articles that we expected to print in the present volume. Most of these have been published in our pages, but, owing to various circumstances, some of the gentlemen who had promised papers found it impossible to prepare them. We have made arrangements for the following articles, which we expect to publish in the eleventh volume of this JOURNAL:—

Prof. MARK W. HARRINGTON. "The Texan Monsoons." "The General Features of the Rainfall of the United States."

A. LAWRENCE ROTCH. "The Meteorological Service in Great Britain." "Results of Barometer Comparisons with the South American Standards." "The Effect of Great Pressure Changes on Aneroid Barometers." "An Account of the Meteorological Services in South America." "Meteorological and other Observations during the Total Solar Eclipse of April 16, 1893."

Prof. CLEVELAND ABBE. "The Relation of Geodesy and Meteorology."

Prof. W. M. DAVIS. "Control of Topographic Expression by Climate."

- Prof. H. A. HAZEN. "Progress in Weather Forecasting." "Fog Signals and Meteorology." "Extra-Terrestrial Sources of Energy in Meteorology." "Results of Scientific Balloon Ascensions by the Signal Service." "Temperature* Conditions and their Changes at all Heights in the Atmosphere."
- Prof. WINSLOW UPTON. "Cyclonic Precipitation in New England."
- R. F. STUPART, Meteorological Office, Toronto. "Thunderstorms in the Province of Ontario."
- F. B. WHITE. "Topographic Winds." "The Winds of the North Polar Regions."
- R. DeC. WARD. "Meteorology as a University Course." "Recent Foreign Studies of Thunderstorms." "The Newspaper Weather Maps of the United States." "List of References for Systematic Reading in Elementary Meteorology."

We propose to publish shortly a view of the new Harvard College Meteorological Station on the Misti, in Peru, the highest meteorological station in the world (see this *JOURNAL* for February, 1894, pages 433-4). As an aid in teaching meteorology in schools and colleges we propose also to publish a list of photographs and of lantern slides which will be useful in teaching, and which may be easily secured. These views will include clouds, lightning, tornado effects, storm waves, etc., and will be accompanied by brief explanatory text.

We desire to call the attention of our readers to the foregoing list of articles and to ask them to show the prospectus of our next volume to all persons whom they know to be interested in meteorology. We want, during the coming year, to increase the circulation of the *JOURNAL* considerably, in order that we may add new features of interest and value, and we ask the co-operation of our present readers in making the *JOURNAL* more widely known. We feel that the program we have mapped out is an attractive one, and we trust that our readers will support us in our efforts to improve our magazine.

The Weather Bureau Notes, which we used to print with our Current Notes, had to be discontinued for a few months, owing to unavoidable circumstances, but we have now made arrangements to continue them as heretofore. The list of Titles of Recent Publications, printed monthly under our Bibliographical Notes, and which many of our readers have found of much value, will also be continued. This list is furnished to the *JOURNAL* through the kindness of Mr. Oliver L. Fassig, the Librarian of the United States Weather Bureau at Washington, and is therefore a complete and authentic one. ROBERT DeC WARD.

STORMS OF THE GULF OF MEXICO AND THEIR PREDICTION.

WILFRID D. STEARNS, PRINCIPAL ROSENBERG SCHOOL, GALVESTON,
TEXAS.

OF the storms of the United States none are more destructive than many of those entering the country from the Gulf of Mexico. They may be divided into three groups: *First*, are the depressions of comparatively little intensity which form in Northeastern Mexico or Southwest Texas, frequently as a secondary to a depression entering from California. They occur principally in the winter months, move southeast, then east and northeast, up the Mississippi Valley or along the Atlantic coast. They are similar in all respects to the storms of the middle latitudes and are of little local interest. *Second*, are those West Indian hurricanes which originate on the northern border of the Equatorial Calm Belt, and move westerly and northerly, only recurring to the northeast in the Gulf of Mexico. The subtropical storms forming in the southwest Gulf comprise the *third* group. Originating as they do on the northern border of the summer rain belt, they follow almost the track the West Indian hurricanes pursue on reaching the same region. The last two classes may be considered as one, since the storms included in them present identical characteristics in the northern Gulf. They are very destructive and give almost no indication of their presence through the barometer or other meteorological instruments. Particularly is this the case under certain conditions. Fortunately these storms are likely to occur only through the months from July 1 to November 31.

The study of the local conditions and cloud movements preceding their approach to the coast has led me to believe that in every case their presence may be detected some hours in advance of their arrival. Yet, in predicting such a storm, care must be exercised to see that there is nothing in the telegraphic reports which preclude its existence. I give below, briefly, certain generalizations which I consider of value. The third principle is, perhaps, most worthy of emphasis.

On the passage of a disturbance through the northern Gulf or on its approach to the coast from the southward :—

I. If the pressure over the southern United States is generally normal, that is within two tenths inches, wind and barometric evidence is present at Gulf ports before local conditions indicate a disturbance.

II. If the pressure to the northward is decidedly above the normal, the wind indications are disguised by the out-flowing circulation from the "high" and barometric evidence by its easterly retreat. In this case local conditions will decide whether or not the storm is present twelve to forty-eight hours before it is possible to determine the question by other means.

III. When a decided depression exists to the northwest, north, or northeast, especially an extended "low" covering the central Rocky Mountain slope, the northern "low" governs the surface wind until twenty-four to forty-eight hours after local conditions have made the storm's presence evident. The low barometer naturally to be expected here on the approach of the secondary is at first hidden in the general depression.

LOCAL PHENOMENA.

(a) *Of the Sea.* — (1.) Twelve hours or more before any other indication of the storm's approach, the surf at this point increases in intensity. The sea continues rough until the storm centre has passed far to the eastward. Instead of a simple undulation, two distinct wave motions, making an angle with each other of about sixty degrees, may be noted. This system swings as a whole towards the east with the passage of the disturbance in that direction. (2.) A great increase in wave length is early noticeable. (3.) A marked and quite sudden rise in the tide occurs without wind, or a sufficient increase in a favorable wind, to account for it. This increase is entirely distinct from the gradual piling up of the water which takes place under the influence of a gentle but constant southeast wind, although a steady wind may produce ultimately an even higher tide.

(b) *Cloud Indications.* — (1.) If detached cumuli of considerable vertical extension are present in an otherwise clear sky (they usually occur with a "low" to the northward, seldom with a "high" in that position until the near approach of the storm), the

column early shows a tendency to incline toward the southwest. In a few hours the upper portion of such columns is observed to possess a motion from north of east to south of west. This is simply the cyclonic motion with reference to a storm in the southeast, and of itself indicates a disturbance in that direction. When a band of high cumulus topped with or piercing cirro-stratus is present along the southeastern horizon, and shows this motion, an extended storm exists in that quarter. The reverse direction, southwest to northeast, seems to indicate that the disturbance is local. (2.) A sheet of thin cirro-stratus evident in the southeast, but possessing a nearly south to north motion, and covering a greater and greater segment of the sky, particularly if this sheet has a uniform structure and little broken front, indicates a storm well to the southward. More exactly, [and when taken in connection with the sea indications, much haziness in the southeast, with the waves tending well from the eastward, indicates that a storm probably exists in the eastern Gulf and that it is very distant. Cumuli in the southeast, with little cirrus, forming a band along the southeastern horizon, the cumuli having a north of east to south of west motion, and the whole mass rising toward the zenith, little or not at all, indicate a storm well to the east of south. A uniform sheet or veil of cirro-stratus in the southeast, only detached cumuli being noted, but these possessing in their upper portion a from north of east to south of west motion, indicates a storm to the southward. Cirrus from the southwest; no high cumulus; cirro-cumulus from the southeast or east, indicates a storm in the southwestern Gulf.

The writer has not learned that the motion of the higher cumulus from north of east to south of west is ever observed in the central and northern United States except in summer showers. He attributes the fact that it is seen here to the rapid rotary and slow progressive motion of these storms. The fact that the higher cumulus over a given locality may circulate about a southern storm centre while the lower cumulus and surface wind move in obedience to the indraught of a northern low pressure area, seems worthy of further investigation.

These storms originate in a vortex motion in a region where the heat and moisture of the atmosphere are excessive up to a very considerable altitude. The almost daily condensation tak-

ing place in the ascending currents at the season when these disturbances occur gives rise to an accumulation of heat which is only partially relieved by radiation and the slow poleward progress of the higher easterly current. As soon as a vortex motion on a large scale is fairly established, the condensation is so abundant and rapid that the potential temperature of the more elevated portions of the column becomes very much higher than that of the surrounding atmosphere. The descent being nearly adiabatic, the actual temperature soon becomes so high that the lower and cooler air strata cannot be displaced; however, the air can and does expand in one direction,—toward the storm centre. Flowing towards it and cooling, it makes a gradual descent while the cyclonic motion, at first feeble, becomes more and more rapid. When the current first partakes of the cyclonic motion it is at the height of the higher cumulus clouds. When near the storm centre it has become a surface current. Incidentally this explains the high wind velocity which is at once apparent when a given locality comes within the influence of the cyclone, for this same air has, as an upper but descending current, been gyrating around the storm centre for a considerable time. I look upon such a storm as somewhat resembling an inverted truncated cone of large base and, corresponding with other storms, of considerable altitude.

I give below an account of the phenomena preceding a number of the Gulf storms of 1892 and 1893. Notes were taken in some cases and are herein reproduced; in others, no notes were kept, but some accompanying circumstances fixed the characteristics of the storm upon the mind.

1892. September 7 to 12, the barometer being nearly normal to the northward, a storm passed across the northern Gulf. This disturbance was abundantly indicated here and at Corpus Christi by wind and barometer as shown on the government maps.

In October, about the 14th, a "low" existing to the northward, a band of cumulus capped with cirrus was observed in the southeast. It possessed a motion from north of east to south of west. On the following day it had risen somewhat toward the zenith. For an hour or two in the morning the wind blew quite briskly from the northeast. "Low" stratus and cumulo-stratus, also moving from the northeast, appeared. The southeastern segment of the sky took on a very cyclonic aspect. The wind

shortly again changed to the southeast. During the day the band of high cumulus persisted in the southeast, while its northeast to southwest motion was distinctly visible. On the third day the band still remained, but was capped with more cirro-stratus, and it was observed that its motion was much less rapid than on the two days preceding. In the afternoon no motion could be detected. This disturbance did not reach the United States, but a storm occurred about the same date at Vera Cruz, Mexico.

On October 22, a "high" being to the northward, during the morning a sheet of cirro-stratus appeared above the southeastern horizon and moved slowly northward over the sky. High cumulus was observed in the afternoon moving from the north of east to the south of west. There was some thunder and a sprinkling of rain. The general appearance of the southeastern segment of the sky became very cyclonic, but the northwestern segment was at no time covered with clouds. This storm was afterwards indicated on the government map as central at Titusville, Florida.

November 5. No observation was made.

On November 6, a "low" existing to the northeastward, a terrific thunderstorm occurred in the early morning. The lower clouds cleared away about 10 A. M., the wind at that time being light from the west, afterwards becoming southwest. At the same hour the higher cumulus was observed moving with exceptional rapidity from northeast to southwest along the southeastern horizon. During this storm a tornado occurred on the southwestern portion of Galveston Island.

November 7. A "high" existed to the northward. In the morning the wind was northwest. About 9 A. M. a sheet of cirro-stratus was observed in the southeast, which extended gradually over the sky.

November 8. The wind was northeast, and the rain began falling about 8 A. M.

November 9. A storm was indicated on the government map, central at Mobile, Ala.

1893. On September 5 to 8, a "low" existing to the northward, a storm passed through the northern Gulf. It was distinctly indicated here and at other Gulf ports by the wind indications and by the barometer. On September 7 and 8, it

was central at New Orleans. On the evening of the 8th, higher cumulus with a little cirrus could be observed lying along the southeastern horizon. These clouds possessed a distinct north-east to southwest motion. On the morning of the day following they were still visible, and possessed the same motion. As such storms as this, namely, those giving rain at Galveston but central in the Gulf, pass eastward, the sky presents nearly the same successive aspects, but in a reverse order, as it does on the approach of a storm coming from the southwestward, but passing to the southward of this city.

I give below, verbatim, notes which were jotted down by me during the Gulf passage of the New Orleans storm of October 2, 1893. My attention was first called to the probability of a serious disturbance on Friday night, September 29, when a tide which was unusually high for the phase of the moon occurred, a very moderate wind then prevailing. The wind was south when the notes of September 30 were made.

"4 P. M. At 12 M. to-day (September 30), I wrote to the New York *Herald*, and mailed the letter in the post-office box at 3.30 P. M., stating that I believe a secondary is central in the Gulf, a little east of south, distant two hundred and fifty miles. I infer its presence from the fact that cirro-stratus clouds forming a thin sheet have been rapidly rising in the southeast during the morning. The general structure shows that the storm from which it comes must be at a distance, otherwise it would be heavier in streaks, *i. e.*, not so uniform.

"The front edge of the cloud being nearly straight, proves that it comes from a storm of considerable extent in contradistinction to a shower. Its rapidity of rise indicates that there must be a strong outward flow of air from the top of the storm. The top of the cumuli incline to the west, but none have appeared in such position that it could be determined whether they have any actual westerly motion. Westerly motion in the higher currents I consider an indication of a storm to the south, southeast, or southwest.

"At this hour, the cirro-stratus has risen beyond the zenith, and the wind has become southeast. I think the wind will become east before morning, that it will be cooler and threatening to-morrow with rain in the afternoon or night, and a 'high' following the 'low' passing across the northern United States will

give strong northeasterly and northerly winds Monday and Tuesday." It is evident that at this time I expected the storm to follow a path to the northward of its actual track.

"7.45 A. M. October 1. Sky covered with cirro-stratus more dense than yesterday, but the sun and moon show through it. High cumulus and upper lower cumulus have a slow motion from the northeast. The lower clouds have too little motion to detect. Wind southeast; light and fitful. Very sultry. Sea rougher than yesterday. Heavy bank cumuli in the east. It seems that the storm is moving a little more slowly than expected, but I think the wind will certainly become east before noon to-day.

"8.8 A. M. October 1. An examination of the sky from the roof of shed shows cirrus does not extend over northwestern segment of sky. I infer from this that the storm centre is approaching very slowly either because it is moving very slowly, or because it is following a course to the east of north, that is, more to the east than seemed probable on September 30.

"8.22 A. M. Wind has just changed to the northeast. It remained northeast only a few minutes, changing to east.

"8.55 A. M. Wind now east. Lower cumulus has a slow motion from south.

"6.10 P. M. Sky covered to about the same extent as this morning with cirro-stratus. Less cumulus. Striæ to-night radiate more to the west than this morning. Wind southeast. It has varied between east and southeast a greater part of the day. Surf same as this morning with a heavy audible swell." ("Audible swell" here means that the alternate rise and fall in loudness of the sea's roar was evident at my home more than a mile from the beach.)

Sunday morning, any doubt which might have existed in regard to this storm was set at rest by the distinct northeast to southwest motion of the high cumulus. The latest government reports to which I had access were those of Saturday morning, September 30. If I had known that the reports taken Saturday and Sunday morning gave no indication of this cyclone's presence, I should have been tempted to telegraph the conditions, so evident were they.

To show the indicative value of sea indications, I add the following:—

"Oct. 16, 7 P. M. Cirrus and cirro-cumulus from the south-

west and southeast respectively, point to, but by no means conclusively indicate, a storm in northeastern Mexico, or in the extreme southwestern Gulf. I should place it five hundred miles distant. It should be indicated on to-night's map. Later : No indication on map.

"Oct. 17, 7.45 A. M. Weather clear but hazy in the southeast. A rough sea this morning caused me to visit the beach. *Very* rough. A high tide rapidly coming in. A clear cirrus indication will be sufficient evidence to *prove* the existence of a storm, since the high cumulus observed yesterday had an almost imperceptible motion.

"Oct. 18, 7 P. M. Moderately high cumulus was observed at 1 P. M. to-day. It had a rapid east to west motion. I wrote to the New York *Herald* at 11.15 A. M., saying that a storm existed in the Gulf. I placed it four hundred miles due south. The United States Weather Bureau sent warning in the afternoon of a severe storm south of Port Eads, moving north."

It should be remembered that the path of storms which make the circulatory passage of the Gulf, or northern portion of it, lies between two hundred and two hundred and fifty miles from this city in a direction about south by east. Granting that higher cumulus and cirrus may be observed when as far distant as seventy-five miles, a cloud area with a diameter of no more than three hundred and fifty miles, would be distinctly visible here. A storm can hardly pass us, therefore, without being detected. Frequent and careful observations are, however, necessary, to determine these cloud movements when the cumulus masses are near the horizon.

PAPERS FROM THE PHYSICAL GEOGRAPHY LABORATORY
OF HARVARD COLLEGE.

NO. II. — A NEW CHART OF EQUAL ANNUAL
RANGES OF TEMPERATURE.

J. L. S. CONNOLLY.

THE chart herewith presented of Equal Annual Ranges of Temperature was constructed on the basis of Dr. Alexander Buchan's "Challenger" isothermal charts,* showing the mean temperature, in degrees Fahrenheit, of the world in January and July. The following method was adopted in obtaining the lines of variation shown on this chart:—

A careful tracing of the July isotherms was first made. This tracing was then placed upon the January chart, thus revealing the points where the isotherms of one map crossed those of the other. These points, and the number of degrees of variation they separately represented, were then entered upon the tracing paper. In addition, by interpolation, the values at the intersections of the latitude and longitude lines of the map were found. Other points were determined in the same way, by interpolation, where needed. From the data thus obtained a new tracing was made, which showed the lines of equal annual variation of temperature, and when this was finished the outlines of the land forms were entered on it.

Supan has drawn a map of the temperature differences of the warmest and coldest months, but he did not have the advantage of the abundant material which has been furnished us in the results of the "Challenger" expedition.† These results, so ably discussed by Buchan, have made it possible, on the present chart, to draw lines of equal temperature differences of more accuracy, and to give a far greater degree of precision to the lines in the region near the North Pole.

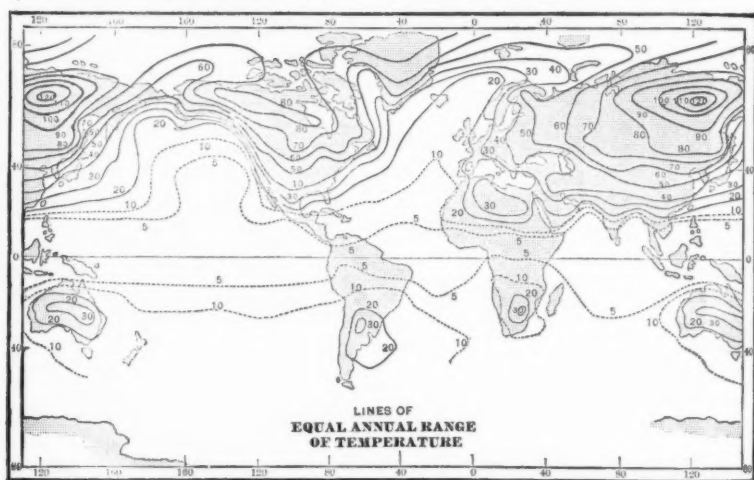
An examination of the new chart reveals the following facts:—

The Torrid Zone is on the whole a region of moderate annual range of temperature, as the annual range of insolation is small, while the North Temperate Zone has extreme variations as compared with the South Temperate, and the Northern Hemisphere

* *Report on Atmospheric Circulation*, "Challenger" Expedition, London, 1889.

† *Zeitschr. wiss. Geogr.*, I, 1880, 141.

has, as a whole, greater ranges than the Southern. The reason for this is that water areas, being, as is well known, conservative elements, vary little in temperature from season to season, while land areas change their temperatures much more readily. The effect of insolation on and radiation from land areas in producing great temperature ranges is well shown on the chart. In northern Asia there is a range of 120° ; in northern North America, 80° ; in Northern Africa, Australia, South Africa, and southern South America, 30° . It will be noticed that the areas



are all far from the equator, and the regions of greatest range are in the Northern Hemisphere.

A pretty illustration of the conservative effect of water areas is shown in the contrast between the western and eastern coasts of some of the large land areas of the North Temperate Zone. The prevailing winds of the temperate latitudes are from west to east, and therefore blow upon the western coasts of the continents. These regions are therefore mild in winter and cool in summer, and have somewhat of an insular climate, with small annual variations of temperature. Over the eastern coasts, on the other hand, the winds come from the great land masses, which are cold in winter and hot in summer, so that these coasts have a climate which is more continental in character, the ranges of temperature being large.

CURRENT NOTES.

The Teaching of Meteorology in the Schools.—At a meeting of the National Educational Association held July 9, 1892, a Committee of Ten was appointed to investigate and report upon Secondary School Studies. This committee was made up as follows:—

Charles W. Eliot, President of Harvard University, Cambridge, Mass., Chairman; William T. Harris, Commissioner of Education, Washington, D. C.; James B. Angell, President of the University of Michigan, Ann Arbor, Mich.; John Tetlow, Head Master of the Girls' High School and the Girls' Latin School, Boston, Mass.; James M. Taylor, President of Vassar College, Poughkeepsie, N. Y.; Oscar D. Robinson, Principal of the High School, Albany, N. Y.; James H. Baker, President of the University of Colorado, Boulder, Col.; Richard H. Jesse, President of the University of Missouri, Columbia, Mo.; James C. Mackenzie, Head Master of the Lawrenceville School, Lawrenceville, N. J.; Henry C. King, Professor in Oberlin College, Oberlin, Ohio.

The Committee of Ten held a meeting at Columbia College, New York, from Nov. 9 to 11, 1892, all the members being present. After a preliminary discussion on Nov. 9, the committee decided, on Nov. 10, to organize conferences on the following subjects: 1. Latin; 2. Greek; 3. English; 4. Other Modern Languages; 5. Mathematics; 6. Physics, Astronomy, and Chemistry; 7. Natural History (Biology, including Botany, Zoölogy, and Physiology); 8. History, Civil Government, and Political Economy; 9. Geography (Physical Geography, Geology, and Meteorology). They also decided that each conference should consist of ten members. These members were selected in regard to scholarship and experience, to the fair division of the members between colleges on the one hand and schools on the other, and to the proper geographical distribution of the total membership.

The Conference on Geography, which included Physical Geography, Geology, and Meteorology, consisted of the following gentlemen:—

Prof. Thomas C. Chamberlin, University of Chicago, Chicago, Ill.; Prof. George L. Collie, Beloit College, Beloit, Wis.; Prof. W. M. Davis, Harvard University, Cambridge, Mass.; Delwin A. Hamlin, Master of the Rice Training School, Boston, Mass.; Prof. Edwin J. Houston, Central High School, Philadelphia, Pa.; Prof. Mark W. Harrington, The Weather Bureau, Washington, D. C.; Charles F. King, Dearborn School, Boston, Mass.; Francis W. Parker, Principal of the Cook County Normal School, Englewood, Ill.; G. M. Philips, Principal of the State Normal School, West Chester, Pa.; Prof. Israel C. Russell, University of Michigan, Ann Arbor, Mich.

This Conference held sessions on Dec. 28, 29, and 30, 1892, at the Cook County Normal School, Englewood, Ill., and their report, together with the

reports of the other Conferences, has recently been published by the United States Bureau of Education, Washington, under the title, "Report of the Committee on Secondary School Studies appointed at the Meeting of the National Educational Association, July 9, 1892, with the Reports of the Conferences arranged by this Committee and held Dec. 28-30, 1892." From the extremely valuable and suggestive Report of the Conference on Geography, the following paragraphs in regard to the teaching of meteorology in the schools are taken:—

"Since the establishment of the national Weather Bureau, meteorology has not only been greatly advanced as a systematic science, but it has become a subject of wide popular interest. This, together with its importance as a factor of geography, moves the committee to recommend that meteorology be introduced as an elective study for half a year in the third or fourth year of the high-school course, when practicable. Elementary physics should precede it. It should be opened by local observations of the passing weather changes, accompanied by a study of a series of daily weather maps, and the application of physical principles to explain the general phenomena of the atmosphere should follow. Local observations should be carried further in this course than they extended in earlier years, especially regarding the sequence of phenomena in the atmosphere and the correlation of various weather elements. The study of weather maps, already familiar objects from the less systematic study of earlier years, should now reach to the clear understanding and description of the distribution of temperature and pressure, flow of the winds, and occurrence of clear, cloudy, rainy or snowy areas, and to a careful induction of generalizations by which various phenomena are connected; for example, the correlation of the direction and velocity of the winds with the value of the barometric gradient; or of areas of high or low pressure with the spiral outflowing or inflowing winds and the areas of clear or cloudy and rainy sky. The effect of the progression of these areas of high and low pressure on local weather changes and their value in weather prediction should be made clear; practical exercises should be given in this connection, as will be more fully explained in a later section. During the advance of local observation and study of the weather maps, instruction should be given on the more general relations of the science, in which the following headings are the most important: Composition and offices of the atmosphere; arrangement of the atmosphere around the earth under the action of gravity; the nature of solar energy and its distribution over the earth and through the year; the different actions of solar energy on air, land, and water; the mean annual and seasonal distribution of temperature over the earth; the processes of local and general convection; evaporation, humidity, clouds, rainfall; the distribution of atmospheric pressure, and the general circulation of the atmosphere, as modified by the annual march of the sun north and south, and by the influences of the continents; storms, both cyclonic and local; weather changes and their prediction; climate, zones, and their relation to habitation.

"*Methods of Teaching Meteorology.* (a) *Intermediate or Grammar School Course.* The simplest facts concerning the weather may be introduced into observational studies as early as the teacher desires. These

should be followed by simple instrumental records in the fourth or fifth year, never so complex or frequent as to be burdensome, so that when the sixth and seventh year of school is reached, the scholar will have gained an elementary but practical and familiar acquaintance with the use of the thermometer, the wind-vane, and the rain-gauge. The barometer and hygrometer should be introduced, if possible, but not so early as the simpler instruments. Habits of punctuality, care, neatness, and system may be taught by keeping a record, and excellent arithmetical practice may be given in determining averages and totals; but the teacher should take care that the scholars' attention be directed to the phenomena of atmospheric changes, as well as to their instrumental records.

"Accompanying the local observation of weather elements, a simple study of weather maps should be introduced; but this should progress very slowly, in order that the best value may be derived from it. The following suggestions may be of service in this connection. Assuming that the school can receive a supply of daily weather maps for at least a part of the school year, and that it has access to maps received in earlier years, let the teacher select several of the older maps on which the winds over the country east of the Rocky Mountains happened to be moving in a systematic manner, for example, a great volume of southerly winds moving northward from the Gulf up the Mississippi Valley and inland from the South Atlantic Coast, while westerly winds are advancing across the great plains; or a broad sweep of westerly or northwesterly winds spreading all over the eastern half of the country, as during a cold wave. Draw the wind arrows in heavy black lines, for easier seeing; such work as this may often be entrusted to advantage to some of the better draftsmen among the scholars. In order to enforce the idea that the whole lower part of the atmosphere is moving, and not simply the winds at certain stations of observation, draw many intermediate lines, accordant with the directions of the wind arrows; the length, or heaviness, of these lines may be made to indicate the velocity of the winds. A series of charts may thus be prepared with little trouble, from which an effective presentation of some of the greater facts of meteorology can be easily and clearly made. These maps may be used as the basis of exercises in writing; the description of their wind movements deserves careful statement. When the spiral winds about areas of high pressure and of low pressure are included in the series, the scholars will find all their powers of verbal description called on to enable them to state the facts properly. The continued use of the maps will also serve to impress many geographical facts on the memory.

"Areas of cloud and rainfall may be treated in a similar way; and their contrast with adjacent areas of fair or clear sky afford much material for study and description. The presence of clear weather in one region, while heavy rains are falling in another, is thus taught in a simple and effective manner.

"The distribution of temperature should be introduced, first, by entering the thermometer readings at the various stations on the map in strong figures, so that a class may easily see them; and then asking for verbal statements concerning the warmer and colder parts of the country. By selecting

maps in which temperature contrasts are distinct, many interesting exercises may be developed in this manner. When the idea of distribution of warmer and colder areas is gained, it may be suggested that one of the class draw a line to separate all that region which is warmer than 60° , for example, from the region colder than 60° . Similar lines may be drawn by other scholars on other maps. Summer and winter maps may be compared. When the lines are familiar, they may be named 'isotherms.' If the subject is one in which the teacher takes especial interest, and which therefore properly receives more extended treatment than it might otherwise, an additional exercise may be made on a series of lines at right angles to the isotherms (the lines of temperature-decrease, or the 'thermometric gradient' lines) along which the most rapid decrease of temperature would be experienced. Their trend is generally northward, but on certain occasions their course is peculiarly deformed eastward or westward.

"Barometer readings should be treated in the manner outlined for temperatures. The small difference of their values will soon be noted; and the frequent occurrence of limited oval areas of slightly higher or lower pressure than that of their surroundings will soon attract the attention of the scholars. As with temperature, so here, an examination of the curved lines at right angles to the isobars, along which the pressure decreases, will prove instructive; these lines will converge towards the centre of low pressure areas, and diverge from the centre of high pressure areas. When the isobaric lines are close together, the lines of pressure-decrease should be drawn heavier, to indicate a rapid decrease of pressure. The rapidity of decrease of pressure, as indicated by the closeness of adjacent isobars, should be compared on different maps. When the rate and direction of decrease of pressure can be talked about familiarly it may be spoken of as 'barometric gradient.' By slow and patient work, even this relatively advanced idea will be grasped by children in the grammar school; but to attain success, it is of the utmost importance that the work should progress no faster than the scholars ask for it by their behavior with the maps. It would be better to have the work thus far outlined extended over occasional exercises for a year than to hasten too fast, making apparent but unreal, unsubstantial progress.

"When examples of winds, temperatures, clouds, rainfall, and pressures have been given in sufficient number, a combination of two elements, as wind and pressure, may be introduced; and here, in particular, the scholars should be given time to discover for themselves the simple relations existing between two such elements. We are persuaded that the error is commonly made, in schools where weather maps are used, of going too fast under the lead of the teacher's brief explanations, perhaps because the teachers themselves are not yet familiar enough with the great lessons that the maps may give; thus not only passing over many matters with insufficient understanding by the scholars, but also preventing the practice in discovery which here develops so great an interest among children when they are in a properly awakened state, and which gives well-trained scholars so strong an encouragement in their studies. The teacher should supply maps in a proper order, he should guide the advance of the class by judicious questions; but

he should leave them to find out the simple meteorological laws, such as those which associate the movement of the winds with the distribution of atmospheric pressure; the variation of temperature with the direction of the winds, etc. In this way, the following principles may be established: The winds flow towards the regions of lower pressures, but they generally turn a little to the right of the lines of pressure-decrease, that is, to the right of barometric gradient. The winds blow faster when the pressure decreases rapidly, and calms or light breezes prevail where the pressure is comparatively equable. The winds blow in left-handed curving spirals in areas of low pressure, and in right-handed outward spirals in areas of high pressure, and they are generally stronger in the former than in the latter. Southerly winds cause a rise of temperature; northerly winds cause a fall of temperature. Areas of low pressure are generally cloudy, with rain in summer, and with rain or snow in winter; areas of high pressure are prevailingly clear with warm days and cool nights in summer, and with cold weather and extremely cold nights in winter. These areas move in a general eastward course over the country, carrying their changes of wind and weather with them, in such a manner that the stationary observer suffers changes from clear to cloudy weather, and from warm southerly to cool northerly or westerly winds as they pass. Thunderstorms of summer time generally occur in the southeastern quadrant of low pressure areas.

"During the advance of this work, current weather maps may be introduced to give exercise on the problems in hand, whenever they serve the purpose well. A connection may thus be made between the local weather noted at the school and the general atmospheric conditions over the country; and a passing rainstorm, or a strong change of temperature, may be thus traced with great interest and profit. All through the work, continual practice should be maintained in formulating and writing the conclusions reached by study. As the study advances, these written records become, in effect, so many compact generalizations in which the scholars' inductions are preserved. The training of mental powers and the encouragement given to persevering and intelligent study are not among the least of the results gained from work of this kind.

"Without going further through an account of elementary exercises, based on the weather map and illustrated by local weather observations, we may add a few examples of subjects that may be borrowed from meteorology for the aid of descriptive geography. The prevalence of westerly winds, and the general advance of areas of high and low pressure from west to east, may be mentioned as one of the strongest characteristics of the middle temperate zone; and in contrast, the oblique northeast and southeast trade winds, blowing steadily, with few stormy interruptions, may be instanced as a prevailing characteristic of the torrid zone. The greater intensity of weather changes may be pointed out as a feature of winter, when we experience something of frigid conditions; the less intensity of weather change is a feature of summer, when we are visited by almost torrid heat. The general increase of rain or snow within areas of low pressure, as they approach the Atlantic Coast, may be used to explain the aridity of our western interior region, and of other continental interiors.

The smaller variations of temperature near the coast, and particularly on the Pacific Coast, than in the upper Mississippi Valley, may be employed to teach one of the greatest climatic contrasts of the world.

"(b) *High School Course.* The course in meteorology in the high school should be directed quite as much towards a training in the methods of logical investigation, as towards imparting information concerning the science. It should not be attempted until after a course in physics is passed. For the sake of brevity, only the shortest outline of the work can be introduced.

"Facts of local observation about the school and of extended observation through the weather maps bring almost continuous but variable movements of the atmosphere before the class. The correlations discovered from the weather maps in the grammar school, now reviewed, show a clear connection between the movement of the winds and a variety of the other weather elements. Let it, therefore, be suggested that the cause of the winds be the main line of study, leaving the associated phenomena to be examined and explained in their natural connection with the winds.

"Recalling the teaching of physics, it appears that no cause for atmospheric movement is so available as convection, that is, a gravitative circulatory movement excited by differences of temperature. Under assumed conditions as to temperature, the resulting distribution of atmospheric pressure and flow of the winds may be deduced in accordance with accepted physical principles, and this process may be at once contrasted with the inductive process by which the correlations of the weather maps were established. It may be then stated that if the distribution of temperature over the earth were known, the general circulation of the winds and the distribution of pressure could be predicted, and, according to the closeness of agreement afterwards found between these predictions and the facts, the theory of the convectional cause of the winds would be accepted or rejected, thus introducing the class to a rational method of scientific investigation, applicable in all manner of studies, as well as in meteorology.

"On perceiving the direction thus given to further inquiry, the study of the control and distribution of atmospheric temperature is naturally taken up, because it is manifestly needed before further advance can be made. Under this division of the subject, the teacher is advised to make clear the distinction between radiant solar energy, which traverses the celestial spaces in all directions from the sun, and of which a very small part reaches the earth, and the heat produced when this energy is acquired or absorbed by terrestrial matter. Interesting illustrations of physical processes are found in this connection; the different rates of absorption of radiant energy by air, water, and land, the control of temperature by specific heat, latent heat, dynamic cooling of ascending air currents, etc., etc.

"The distribution of temperature on annual and seasonal isothermal charts may next be studied, noting the prevailingly high and uniform temperatures of the torrid zone, the variable temperature of the temperate zone, and the prevailingly low temperatures of the frigid zones; noting also the small variations of temperature from season to season on the oceans, even in

relatively high latitudes, while the lands of the temperate zone have extremely variable temperatures.

"In accordance with the theory of convectional circulation, it is now possible to predict the distribution of pressure, and the flow of the winds, on the assumption that they are entirely the product of differences of temperature maintained by the sun. The predictions should be carefully formulated and entered on a blank map of the world. A series of annual and seasonal charts of pressures and winds should then be compared with the predicted consequences of the theory. It will be apparent that the theory is incomplete, because there are many differences between its predicted consequences and the facts; but all these differences are explained when adequate account is taken of the effect of the earth's rotation in deflecting the winds from the gradients and in rearranging the distribution of pressures. A good understanding of the general circulation of the atmosphere and its seasonal variations may thus be gained. Both the value and the danger of the deductive method, and the importance of continually confronting the consequences deduced from theory with the results of observation may be impressed by this lesson.

"On attaining a rational understanding of the prevailing winds of the world, the consideration of atmospheric moisture and clouds may be introduced before the study of storms and rainfall is approached. In connection with the formation of clouds, the effects of the liberation of latent heat during the condensation of vapor should be deliberately examined, as a matter of much importance in the larger processes of convection.

"Tropical cyclones offer the best introduction to the study of the stormy interruptions of the general circulation of the atmosphere. These cyclones are well-defined phenomena, closely studied in certain tropical seas, and of serious importance as dangers to navigation. The place and season of their origin and the manner of their action point to the conclusion that they are violent convectional whirls, turning in consequence of the earth's rotation, and supplied with much of their energy from the latent heat of the vapor that is condensed to furnish their heavy rains. They exhibit in a small way many features already familiar in the general circulation of the atmosphere around the poles. On coming next to cyclonic storms, and the anti-cyclonic areas of temperate latitudes, which together constitute the regions of low and high pressure in our weather maps, the presumption that they are convectional phenomena is naturally conceived, because convection has been previously found to be so sufficient a cause of the general circulation of the atmosphere and of tropical cyclones; but on perceiving that our cyclones and anticyclones are more frequent and more violent in winter than in summer, their convectional origin cannot be taken for granted, and other causes for their action must be examined. The science of meteorology is at present undecided on this question; although the weight of evidence leans towards explaining the cyclones and anticyclones of the temperate zones as an effect of irregular movements in the general circulation, rather than as independent, spontaneous, convectional phenomena. The absence of a demonstrated settlement of this question is not held to be good reason for excluding the discussion of the causes of these most interesting and important phenomena

from the range of high school study. Students should as carefully learn to hold open opinions on disputed subjects as they are led to believe firmly in the demonstrable propositions of geometry. In all argumentative studies, the evidence leading to the conclusions, and not simply the conclusions, should receive careful consideration.

"The cyclones and anticyclones of our latitudes are found of great importance not only in explaining the changes of weather — as has already been made familiar from earlier study — but also in the determination of the occurrence of local thunderstorms and tornadoes; for these are determined for the most part by instability produced by the importation of warm and cold currents about the areas of low and high pressure.

"The distribution of rainfall is best introduced after the explanation of winds and storms, both general and local. It may be used in confirmation of the explanations already given of the winds — the migrating equatorial rains of the doldrums; the dry belts of the trade winds, except where they blow against mountains; the stormy rains of the westerly winds in temperate and higher latitudes; the subtropical winter rains — all these follow as corollaries of the movements already recognized.

"A general review of the subject may be made under the heading of climate, where the various phenomena hitherto studied separately may now be grouped geographically, and considered especially with regard to their influence on the development of organic life, and on the habitation of various regions by man."

In regard to the methods of teaching in general, the Conference reports as follows: —

"In the discussion of the previous topics, we have necessarily touched upon some of the most vital considerations that bear upon methods of teaching. This is especially true of those that relate to the order of arrangement of the work, the methods of approach to the different phases of the subject, and the mental powers to be cultivated. But in addition to these more general and fundamental suggestions there are considerations that relate to modes of presentation and appliances for illustrative instruction that require attention. The suggestions of the Conference must necessarily be incomplete, and, at the outset, they wish to disclaim any intention of limiting, even by suggestion, the modes of teaching to the methods here briefly outlined. The Conference hold it to be of first importance that every teacher should become so familiar with the subject as to be able freely to depart from any proposed method according as the special conditions of the school shall indicate. At the same time, the Conference feel that the following outlines of the manner in which different parts of the subject may be laid before a class may prove serviceable. Their effort is to suggest briefly and definitely certain modes of treatment of the various parts of the subject, believing that teachers can infer from these the manner in which other parts of the subject may be developed.

"*Preliminary Suggestions.* Inasmuch as all success in teaching depends largely on the ability, training, and opportunities of the teacher, several rather miscellaneous recommendations are introduced, at the outset, relative

to the organization and equipment of the school and the training of the teacher.

"We urge that, in the selection of new teachers, only those be appointed who, by observation and by practice in recording and reproducing their work, have acquired a sufficient knowledge and skill to be able to carry out, themselves, the observations, recordings, mappings, and modellings that are expected of their scholars. We also recommend that familiarity with the modern aspects of physiography be made a requirement of all special teachers of geography, as soon as practicable."

"While urging the acceptance of physiography, geology, and meteorology for admission to college, the Conference do not urge that they should be required. In examinations for admission to college, the Conference suggest that physiography be given preference over other branches of geography, and that political geography be required in connection with history.

"Concerning the class of questions most suitable for testing attainments, this being a subject submitted to the Conference, we suggest two criteria which should be met. The question should be (1) such that no student who is not familiar with them can be supposed to have an adequate preparation, and (2) such that no student who has an adequate preparation can fail to exhibit it by means of them (time and other necessary conditions being granted). These criteria, we think, will be best met by the selection of broad but fundamental topics, rather than by narrow and special questions on which the student might fail although well trained on the subject in general. In attempting to treat the fundamental topics recommended the candidates will show the precise character of their command of the subject. If that is loose and superficial it will appear in their papers; if it is thorough and precise, that will appear; if it is a mere memorized knowledge of facts, that will be shown; if it is a keen analytical perception of causes, agencies, and processes, that will be indicated. When such topics are set, the candidates cannot either succeed or fail by the mere hazard of questions. Their opportunities are ample. And if the judgment on their papers rests, as it should, on the nature of the knowledge and training shown, and not simply on the fact that something has been written, a true estimate may be formed. 'Catch questions' have no place in an examination for college. Among the topics that may be employed in such an examination, the following are selected as illustrations: Forms of projection used in maps; interpretation of topographic maps (as a part of the required work in physiography); the natural history of a river or a land area; the topography of a familiar district expressed by sketch maps and by an outline of the region and history of its topographic features; the significant features of one of the continents and of its drainage systems; the physical features of the United States; the character of ocean basins; the relation of the true continental border to the water line; the essential facts of the distribution of rainfall, of temperature, of atmospheric pressure, and of atmospheric circulation; the character and distribution of glaciers; the distribution of volcanoes, of deserts, and the significance of the latter; cyclones and anticyclones; the distribution of plants and animals."

Influence of Forests and Topography on Hailstorms. — M. Plumandon, of the Puy-de-Dôme Observatory in France, has an article in *Ciel et Terre* for Dec. 16, 1893, on the "Influence of Forests and Topography on Hailstorms." The extended losses which are caused in France every year by the destruction of crops by hail led the French Chamber of Deputies last year to ask the Minister of Public Instruction to carry out an investigation as to the influence of forests on hail-storms. Through the *Bureau central météorologique*, the Minister of Public Instruction addressed a circular to the departmental meteorological commissions, asking the latter to include this subject in their list of investigations.

The departmental commission of the Puy-de-Dôme at once undertook the work. Circulars were sent out to all the mayors in the department, and answers to the following questions were received from 433 of them: —

1. State whether there is a forest or a large wooded area in the territory of the commune.
2. Give the name of the forest or wood, and indicate its position with reference to the chief town in the commune.
3. Show what district (if there is one) is believed to be more exposed to hail than others.
4. Show what district (if there is one) is believed to be less exposed to hail than others.
5. State, if there is room, the reasons generally given to explain the above-mentioned peculiarities.

The answers given to these questions have brought out some interesting points. In 267 cases it is stated that there is an even distribution of hail all over the district, while in 166 communes there is thought to be some local influence at work in causing an unequal distribution of hail. Equally surprising is the fact that in some localities forests, mountains, and valleys are considered to have a tendency to increase damage by hail, while in others, less numerous it is true, they are thought to lessen the damage. In fifty localities mountains are supposed to have an injurious effect, while in nineteen others the opposite opinion is held. Curiously enough, it is in the regions where the mountains are really nothing more than insignificant hills that the greatest injury or benefit is supposed to be due to them. In thirty-four communes valleys are thought to have an injurious effect, while in five cases they are believed to decrease the danger of damage by hail. Plains are thought to enjoy a certain immunity in twenty-four communes, while in three cases they are supposed to attract hail-storms and increase their severity.

This conflicting testimony goes to show that forests and topography have no *direct* influence on the propagation and development of thunderstorms. In addition to the evidence afforded in the answers to the questions, charts were drawn of the localities in which crops have been damaged by hail, of the hail distribution for each year from 1876 to 1892, of the number of hail-storms in each commune, and of the communes which have sustained damage in this way. These maps show that while the regions which have sustained damage are scattered all over the departments, near forests, in valleys, on mountains, on plains, on plateaus, and far from any forest, the

districts which sustain loss by hail are more or less grouped in one or more parts of the departments, varying in different years and including without distinction forests, mountains, plains, and valleys. "We are forced," says the author, "to the final conclusion that the data collected hitherto do not warrant our attributing to the earth's surface any *direct* influence on hail-storms, any more than on thunderstorms. But if the general opinion and the authenticated facts establish the conclusion that forests and the different accidental features of the earth's surface have no direct influence on thunderstorms and on hail-storms, how is it that in certain localities people seriously believe in such an influence? It is because, most likely, the observers, whose good faith we cannot doubt, have labored under a delusion."

Forests, through the moisture under their trees and the water which continually evaporates from them; mountains, through the differences which exist between the temperature of the air over them and that of the surrounding atmosphere, and valleys, by reason of the natural path which they offer to the circulation of the lower winds, often provoke the formation of low clouds during the prevalence of rapid atmospheric disturbances. Clouds thus formed, by reason of their low altitude, are less lighted up than those higher up, and therefore seem to be blacker and thicker than the others, and also appear to be the actual source from whence the thunder, lightning, wind, hail, and rain come. The height of the thunder-clouds is much greater than is usually supposed, and the base of the cumulus clouds of thunderstorms is always higher than the summit of the Puy-de-Dôme (4,813 feet). Hail, as is well known, falls more frequently on mountains and on high plateaus than on plains. This fact, that the thunderstorm clouds are at a high level, leads the author to the conclusion that forests, mountains, and valleys can have no *direct* influence on such phenomena, whose seat of action is so high in the atmosphere. The influence they do exert is essentially only a certain preparation of the atmosphere, caused by an unequal distribution of temperature and water vapor over different parts of the surface. A rather uniform pressure is a necessary condition for the formation of thunderstorms, and they occur usually in the southeast quadrant of a feeble depression, their formation being aided by certain local influences.

The direction of movement depends on the position of the storm with reference to the general distribution of pressure. If this is uniform, the thunderstorm will move from southwest to northeast. If, however, the thunderstorm is under the influence of a large depression, it will follow the general direction of the winds determined by that depression. Thunderstorms are further influenced in their movement by the progression of the main depression, and by the existence of secondary depressions. Finally, some thunderstorms seem to have a movement of their own.

M. Plumandon concludes his article as follows: "It is seen that if the earth's surface does not act directly and in a local way on thunderstorms, it does indirectly and very effectively influence their course, by causing an unequal distribution of temperature and water vapor, thus continually modifying the condition of the atmosphere and favoring the breaking out of local disturbances of which thunderstorms are the perfect types."

Royal Meteorological Society.—The annual meeting of this Society was held on Wednesday evening, Jan. 17, at the Institution of Civil Engineers, Westminster; Dr. C. Theodore Williams, President, in the chair.

The Council, in their Report, stated that the Society had made steady and uninterrupted progress during the year, there being an increase in the number of Fellows, and the balance of income over expenditure being greater than in 1892. They also reported that Dr. C. Theodore Williams, previous to vacating the office of president, had expressed a desire for the formation of a fund for carrying out experiments and observations in meteorology, and that he had generously presented to the Society the sum of one hundred pounds to form the nucleus of a Research Fund.

The President, Dr. C. Theodore Williams, in his valedictory address, gave an account of the climate of Southern California, which he made most interesting by exhibiting a number of lantern slides. In the autumn of 1892 Dr. Williams visited this favored region chiefly with a view of investigating its present and future resources, and its suitability for invalids. After describing the entrance into California from Utah and Nevada, the general geography, and the mountain ranges, he pointed out that the mountain shelter is tolerably complete, and that the protected area consists of (1) valleys, chiefly running into the coast range from the sea and rising to various elevations, such as the fertile San Fernando and San Gabriel valleys, or else (2), more or less extensive plains as those of Santa Ana and San Jacinto. Southern California is subdivided into two portions, eastern and western, by the Sierra Nevada, and its spurs, the San Gabriel and San Bernardino mountains. The climate of the eastern portion, which is an arid region, is very dry, very hot in summer, and moderate in winter. The climate of the western portion has three important factors, viz.: (1) Its southern latitude; (2) The influence of the Pacific Ocean, and especially of the Kuro Siwo current, which exercises a similar warming and equalizing influence on the Pacific coast of North America, as the Gulf Stream does on the western coasts of the British Isles and Norway; and (3) The influence of mountain ranges; these affording protection from northerly and easterly blasts, and also condensing the moisture from the vapor-laden winds blowing from the Pacific. Dr. Williams then gave particulars as to the temperature and rainfall at Los Angeles, San Diego, Santa Barbara, and Riverside. From these it appears that the climate of Southern California is warm and temperate, and, on the whole, equable, with more moisture than that of Colorado; and that it is a climate which would allow of much out-door life all the year round. The President next described the effect of the climate on vegetation, and showed what results had been obtained by diligent watering and gardening in this beautiful region. Wine and brandy are made in South California, but oranges and lemons are the leading crops, varied with guavas, pineapples, dates, almonds, figs, olives, apricots, plums, and vegetables. On higher land, apples, pears, and cherries bear well, and English summer small fruit is also grown; while strawberries ripen all the year round, and are plentiful, except in July and August. Dr. Williams concluded by saying that many an invalid has regained vigor and health, as

well as secured a competence, in the sunny atmosphere of Southern California.

Mr. R. Inwards, F. R. A. S., was elected president for the ensuing year.

New England Meteorological Society.—The twenty-ninth regular meeting of the New England Meteorological Society was held at the Massachusetts Institute of Technology, in Boston, Jan. 27, 1894. Mr. F. B. White, of Cambridge, Mass., read a paper on "Topographic Effects on the Winds of the Weather Maps"; Prof. W. M. Davis showed the proof sheets of his forthcoming text-book of meteorology, and Mr. Robert DeC. Ward, editor of the AMERICAN METEOROLOGICAL JOURNAL, showed and commented upon some recent meteorological publications of interest. Mr. White's paper will shortly be printed in this JOURNAL.

At the annual meeting of the Society in October, Prof. Davis suggested that the action of the Society for the present year might well be directed to the question of meteorology in the schools, where suggestions as to methods of teaching might be of service. In accordance with this proposal a committee, consisting of Profs. M. W. Davis and Winslow Upton and Mr. R. DeC. Ward, was appointed to report upon a plan of action at the next regular meeting to be held in April.

Miss Ellen Hayes, of Wellesley College, was elected a member of the Society.

Weather Bureau Notes.—Part I. of the papers of the "Chicago Congress of Meteorology" will probably be ready for issue during the present month. It will include three sections: I. Services and Methods; II. Rivers and Floods; III. Marine Meteorology. There will be over two hundred pages in this part.

The Weather Bureau will probably soon commence the regular issue of a chart or other publication containing information in regard to Medical Climatology.

The Weather Bureau has done excellent work in forecasting severe storms during the present winter. Among the instances which may be cited to show the value of this work is the following: On Jan. 24, at 1.30 P. M., the maritime exchanges of New York and Philadelphia were warned of dangerous gales, and the observers at Richmond, Lynchburg, Norfolk, Raleigh, Charlotte, Southport, and Wilmington, were instructed to use the entire station force at each point to wire the information to all accessible neighboring points. At 7 P. M. a steamer ran ashore at Cape Henry, Va. The observer immediately wired the Merritt Wrecking Company, at Norfolk, and opened his office for duty. He warned the rescuing party of the impending gale and cold wave, and urged them to exert themselves to the utmost. Through his efforts and timely warning the vessel was pulled off at high water, and in a few hours an intensely severe gale with freezing temperature set in, which would inevitably have resulted in the destruction of the vessel and cargo, had she not been floated on the previous high tide. The ship was the "Rappahannock," bound from Newport News to Liverpool, vessel and cargo being valued at \$600,000.

The observer at Cape Henry, Mr. James Sherry, was at once given an increase in salary in recognition of his services on this occasion.

Secretary of Agriculture Morton says that the Weather Bureau has saved commerce, manufacture, and agriculture during the last four months more than its entire appropriation for the next fiscal year.

Prof. Mark W. Harrington, Chief of the Weather Bureau, has been elected an Honorary Member of the Geographical Society of Peru, and of the *Sociedad Científica* "Antonio Alzate" of the city of Mexico. The Chief of the Bureau is also an Honorary Fellow of the German Meteorological Society.

Prof. Harrington read a paper entitled "Weather Making, Ancient and Modern," before the National Geographic Society in Washington, Feb. 23, 1894.

Bulletin B, of the Weather Bureau, on the "Currents of the Great Lakes," by Prof. Harrington, will soon be ready for issue.

BIBLIOGRAPHICAL NOTES.

PROFESSOR W. M. DAVIS' ELEMENTARY METEOROLOGY.

WILLIAM MORRIS DAVIS. *Elementary Meteorology*. 8vo. Boston, Ginn & Co., 1894. xii.+355 pages. Ch. VI., Figs. 106. Price by mail, \$2.70.

It has long been a source of surprise that in the United States, where meteorology plays so important and public a part, there should be no book on the subject suitable for the reading of the educated public and post-dating the common use of the weather map. This want is now supplied by Prof. Ferrel's "Popular Treatise on the Winds," Dr. Waldo's "Modern Meteorology," and Prof. Davis' new book. Each occupies a fairly distinct field of its own. Professor Ferrel's is essentially dynamic in tone and conception, Dr. Waldo's is essentially practical and applied, and Prof. Davis' is pedagogic and general. With these three books the needs of the general reader in this science are well supplied.

The new "Elementary Meteorology" is evidently the work of a teacher of training and natural aptitude. The subject is well thought out and is consequently well arranged and lucid. The earmarks of the experienced teacher are visible on every page, and most of all in the cuts, which are always good, generally novel, and never type-worn. As illustrative of ingenious and instructive cuts we may refer to the second (on page 21). The representation of the distribution of intensity of insolation of cut No. 2 is very happy, and is suggestive from a purely geometric point of view. Another evidence of the experienced teacher is found in the fact that the proper perspective is preserved through the book. It gives as complete a view of the science as could be expected from any single author, and topics are given their relative importance. It is not a compilation but a digestion of the facts of the science, with the proper amount of theory—and the latter generally brought up to date. The book reminds one of that ancient favorite, Kaemtz's. It is more expanded and elaborate than the modern favorite, Mohn's, but has the same high pedagogic quality.

It is no criticism of a book to say that it leaves out matters which the reviewer would have put in, or *vice versa*. That is a question of the plan of the book or of personal judgment. Besides, it is well not to trouble and confuse the students of the elements of a science with too much about theories still in the formative stage. Yet there are several matters of this sort which might have found their way into such a book and would have proved interesting and suggestive. We note, too, that the author has not recognized some of the more recent advances in the general theories of meteorology; for instance, the general theory of the winds of the globe as deduced mathematically by Dr. Oberbeck and confirmed by the Krakatoa

phenomena, and by Mr. Abercromby's observations of clouds in the Tropics. This theory commends itself thoroughly to students of the dynamics of meteorology and profoundly affects the theories of storms.

The author is a disciple of Prof. Ferrel, in the sense that the latter's studies are used as his foundation stones, and in this can probably be found the reason for the omission mentioned. Prof. Davis gives abundant reference for a text book to his sources of information. Books of this sort should not be loaded up with personal names. A guide, sufficient for the general reader and the student, is given in the preface. The author even goes so far as to encourage his readers to make studies of their own, and suggests several interesting topics. Not a few of the conclusions given in this book are the results of the author's own studies, as is well known to those familiar with the history of meteorology in the United States. For instance, the classification of the winds on page 112 is the author's. As an illustration of the careful study given to features of American weather, it may be noted that Prof. Davis had recognized the monsoonal character of the Texan north and south winds and correctly characterized them. The first detailed study of these winds appeared almost simultaneously with the "Elementary Meteorology," and it does not change, but simply elaborates, Prof. Davis' conclusions.

There is an occasional statement to which exception might be taken. For instance, is it quite correct, as stated on page 31, that "terrestrial rays [that is, heat radiated from the earth] . . . pass out through clear air with about as little loss as the solar rays suffered on entering through it"? The terrestrial rays are generally dark rays, which are readily absorbed by the air. It is the rays reflected from the upper cloud surfaces, and also to some extent from snow, water, and desert surfaces, that pass back with small absorption. Again, on page 150, is it correct to say that "diffusion [meaning the dispersion of the molecules of the vapor of water] is a slow process" compared with convectional distribution? The diffusion here meant involves molecular velocities, under Dalton's law, and is very speedy. Its limitations are those of temperature due to latitude, topography, etc., and not to slowness of motion. The sling-psychrometer, figured on page 149, is a form to which serious objections could be urged and is therefore not the most suitable to be placed before readers as a type. We note that Fig. 63 has slipped out, although it is referred to on page 323.

But flaws can be picked in any book if one sets himself to work to find them. This book is an excellent one and will serve a very useful purpose.

M. W. H.

RAINFALL LAWS.

GUSTAVUS HINRICHS. *Rainfall Laws, deduced from Twenty Years' Observations.* United States Department of Agriculture, Weather Bureau. 8vo, Washington, 1893, 94 pp.

The inadequacy of the rainfall records published by meteorological services has long been recognized by many meteorologists. But the complexity of the phenomena, admitting of an infinite number of combinations of inten-

sity and frequency, has seemed to be capable of satisfactory representation only by the publication of the observations in detail.

A notable memoir by Dr. Gustavus Hinrichs has lately been published by the United States Weather Bureau, in which the author develops methods for the more complete and appropriate presentation of rainfall observations. The monthly rainfall records now published by meteorological services consist primarily of the total amount and the number of rain days. To these are sometimes added the maximum in twenty-four hours, excessive rains, and departures from the normal. In the beginning of his memoir Dr. Hinrichs forcibly calls attention to the fact that these data give a very inadequate idea of the effect of rainfall on the crops, when nothing is told of the order of succession of the rains or the distribution of intensity. The *order of succession* tells how the rains of any period are distributed through that period; that is, for example, whether the rain days were all bunched together or were scattered at equable intervals. The *distribution of intensity* shows what proportions of the rain days, or what portions of the total amount, occur with light, medium, heavy, and flooding rains. Into the important and difficult subject of the order of succession, Dr. Hinrichs does not enter, but confines himself to a discussion of the distribution of intensity. In such a discussion, the first necessity is evidently the adoption of an intensity scale. Dr. Hinrichs has used two scales, differing slightly, but the one with which most of his work has been carried on is as follows:—

Intensity.	Character.	Amount of rainfall per day.
0	Sprinkles.	.01 to .10 inch.
1	Showers.	.10 to .25 inch.
2	Rains.	.25 to .50 inch.
3	Soaking rains.	.50 to 1.00 inch.
4	Washing rains.	1.00 to 2.00 inch.
5	Floods.	2.00 and upwards.

The author classes the rains of 0 intensity as insignificant; those of intensities 1, 2, and 3, as the ones useful to growing crops; and those of intensities 4 and 5 as excessive or damaging.

The intensity numbers, 1, 2, 3, etc., are not simply designations for which letters might equally well be substituted, but they have a definite, quantitative, numerical function. The characteristic is that while intensities increase arithmetically, the total amounts corresponding to them increase geometrically. Hence, in this system, the intensity is proportional, not to the rainfall amount, but to its logarithm.*

A further element of the scale is that the time unit is uniformly the day of twenty-four hours, and not the varying length of each rain. With this intensity scale Dr. Hinrichs has analyzed the number of rain days observed by him at Iowa City from 1871 to 1890. The total number of rain days of

* In elucidating this important fundamental conception, the memoir is unfortunately quite obscure. The term *intensity* is not defined in precise terms, and the footnote which purports to give an analytical definition further confuses the reader by its inaccuracy.

any intensity is defined as the number of days in any specified period on which rain fell to the amount of that rain intensity *or more*. The reader should carefully note, therefore, that this number accordingly represents the total frequency of rains of that intensity *and of all higher intensities*. As thus defined the total number of rain days for the year at Iowa City for each given rain intensity is given in the following table:—

Rain intensity.	0	1	2	3	4	5
Rain height.	.01	.10	.25	.50	1.00	2.00
1871 to 1890.	101.6	60.4	39.8	23.2	10.9	2.4
1881 to 1890.	111.9	68.0	40.6	22.3	9.1	1.9
1871 to 1890.	106.8	64.2	40.2	22.8	10.0	2.1

Dr. Hinrichs then plotted these total rain frequencies as ordinates with the logarithm of the corresponding amounts* as abscissæ, and by his method of treating such curves found that they were closely represented by the equation,

$$\log n = a - b (\log .h)^3$$

where n is the total frequency of rains whose amount is h centi-inches per day, or more. The values of the constants a and b are then deduced for a large number of his own observations, and for observations in widely distant portions of the world, representing many types of climate. The observed and computed values of n are compared, and in general are shown to agree in a most satisfactory manner. In the case of the Norwegian coast only, the equation is modified to the form $(\log .h)^4$ in place of $(\log .h)^3$. The observations thus analyzed enable interesting comparisons to be made between the rainfall of different climates.

A somewhat unnecessary section of thirteen pages, entitled "The Law of Probability," is next introduced, wherein the author develops by his own methods the probability function. Besides being largely unnecessary, portions of this chapter are open to serious criticism. The object of the section, which can be stated very briefly, is to show that the expression above given for the total rain frequency is the same as that for the total probability, and hence that the rain frequency follows the law of probability. The next section is a short one of two pages and one chart, entitled "The Law of Rain Probability," and follows as an application of the preceding section. Although the author has now substituted the term probability for frequency, the two are intended to be essentially synonymous, and it will be simpler to retain the term already used. The author here draws curves of the rain frequency for each intensity, instead of, as before, curves of the rain frequency for each intensity, *and all higher intensities*. Evidently the ordinates for these new curves can be obtained from those first drawn by subtracting each ordinate from the preceding one. These new curves resemble in a general way the curve of probability. Although Dr. Hinrichs has given but two pages and one chart to this form of presenting the rainfall data, it appears to be far more useful in every way than the first method which he has elaborately developed in curves and logarithmic formulæ. It is, in fact, the

* The text incorrectly reads "logarithm of the corresponding intensity."

form which he himself has used when showing in his introductory remarks the need of publishing data suited to the requirements of agriculture. The first method gives the total frequency of rains of each intensity *and of all higher intensities*; the second method gives simply the frequency of rains of each intensity. The latter is undoubtedly what is needed; the combination of rains of *different* intensities apparently serves no useful purpose, but rather tends to obscure the very facts which it is desired to bring out. Although his second form of presenting the data is more adapted to the purpose, the author gives it only two pages, and says nothing about deriving the equations which represent the new curves.

Dr. Hinrichs did not overlook, of course, the desirability of deriving such equations in this case as well as in the preceding one, and an examination of the curves suggests that possibly the agreement between the *observed* values of frequency and the values *computed* from the probability formulæ did not possess a sufficiently marked agreement. If this be the case, that is, if the data presented in this second form cannot be successfully represented by the simple probability formulæ, then the applicability of the total probability formula as derived and used in the first method may properly be questioned, for, as deduced by Dr. Hinrichs, the two formulæ are interdependent. In Section VI., the author investigates the total rainfall as a function of the intensity, and finds that when plotted with the intensities as abscissæ, the curve of total rainfall is in part a rising curve resembling a portion of a parabola, followed by a rapid descent. Evidently no simple function represents the entire line; but Dr. Hinrichs solves the difficulty by using a separate function for each part,—first a parabola, and then a descending straight line, and thereupon enunciates an additional rainfall law. When it is noted that the parabola is determined in general by three or four points and the straight line by only two or at the most three, the laws obtained therefrom require no additional commentary.

The remainder of the memoir is devoted to showing that the linear amount of rainfall is not the proper independent variable with which to derive rainfall laws; and to applying the logarithmic intensity method to monthly and decade periods.

Taking now a general view of the whole memoir, its valuable kernel must be recognized to consist in the important suggestion which is the seed-thought of the whole work, that in meteorological publications, rains and rain days should be analyzed and grouped according to the rain intensity; and Dr. Hinrichs' intensity scale seems to be well adapted to this purpose. With regard to the additional space required for such publication the author says:—

"The above analysis of rainfall, distinguishing six degrees of intensity, involves only *six* columns if we restrict ourselves to the analysis of frequencies, and only twelve columns when taking also the absolute amounts; with the totals of amount and number, the *complete* analysis of rainfall thus involves fourteen columns only. If we can devote seventeen columns to the wind, will it not be possible to devote twelve or fourteen columns to the rain? Is not the rainfall of infinitely greater importance to the farmer, and to almost all people, than wind direction and force?"

The question seems to be well worthy of consideration whether such an analysis of rains as that proposed by Dr. Hinrichs, would not possess a greater utility than the daily and weekly "departure" work now carried on in this country.

GEO. E. CURTIS.

SUMMARY OF INTERNATIONAL OBSERVATIONS.

H. H. C. DUNWOODY, Major, Signal Corps, U. S. Army. *Summary of International Meteorological Observations.* United States Department of Agriculture, Weather Bureau. Bulletin A. 24 x 19 inches. Washington, D. C., 1893. Pp. 10, Ch. 59.

A publication of more than usual interest and value has lately been issued by the Weather Bureau under the title *Summary of International Meteorological Observations.* It consists of a series of fifty-nine charts, 24 by 19 inches in size, and of ten pages of text, and was prepared by Major H. H. C. Dunwoody, of the Signal Corps, U. S. Army, who has been assigned as Acting Chief of the Weather Bureau.

The plan of making daily simultaneous observations through international co-operation was formulated by the International Meteorological Congress which met at Vienna in 1873, and the observations were conducted under the auspices, and largely at the expense, of the United States Weather Service, from 1875 to 1887 inclusive. During this period the number of land stations, exclusive of United States and polar stations, increased to a total of 459, and monthly reports were received from nearly 600 vessels. For the whole period, over 150,000 monthly reports, representing over 5,000,000 daily simultaneous observations, were received and prepared for publication at the office of the Chief Signal Officer in Washington. The establishment of international polar stations was arranged at the Meteorological Congresses held at Hamburg in 1879, and at St. Petersburg in 1880, and in accordance with this plan such stations were established by the United States, Austria-Hungary, Denmark, Finland, France, Germany, Great Britain and Canada, Holland, Norway, Russia, and Sweden.

The material collected during the continuance of the international observations was sent to Washington and there prepared for publication. These publications began with the issue of the Daily Bulletin of Simultaneous Observations, July 1, 1875, which was continued until June 30, 1884. Daily international charts were published from July 1, 1878, to June 30, 1884, and from Oct. 1, 1886, to Dec. 31, 1887. Storm-track charts of the Northern Hemisphere were prepared from November, 1877, to December, 1887, inclusive. A Monthly Summary and Review of International Observations was published from July, 1880, to December, 1887. A tabulated summary of international observations was published from January, 1888, to June, 1889. After this the international work of the United States Weather Service was formally discontinued.

In view of the more or less irregular method of publication, and of the vast amount of data accumulated in these observations, it became very

desirable to have a summary which should present the results in a brief and easily accessible form. The preparation of such charts was begun by First Lieut. (now Major) H. H. C. Dunwoody, U. S. A., in 1886, and in the Annual Report of the Chief Signal Officer for 1891, charts of monthly normal pressure and monthly pressure changes were published and described. These charts have been republished in the present Bulletin, with additional charts and enlarged text. The charts of monthly normal pressure show also the normal temperature, the design of the whole publication being to serve as an aid to forecast officials and observers. Of the new charts, Nos. 26 to 37 show the departure of the normal pressure for each month from the annual normal pressure; 40 to 51 indicate the number of storm centres which passed over each square of five degrees, and the average frequency and direction of movement of storms over the Northern Hemisphere during the ten years, 1878-1887. These last charts show also the track of each tropical storm traced during the same period. Chart 52 shows the aggregate number of storms traced, and Chart 53 the average tracks of storms by months and seasons. Charts 54 to 61 give lines of normal and mean pressure for months of marked variations from the normal temperature over considerable areas of the United States and Europe.

Major Dunwoody and Mr. E. B. Garriott, who has assisted Major Dunwoody in the preparation of this Bulletin, have done meteorologists a great service in preparing these admirable charts, which we have no doubt will be thoroughly appreciated by all who have occasion to make use of them. They will be especially useful for purposes of instruction, an end which we think should be kept constantly in view in the preparation of any charts of this kind. The charts of storm frequency for ten years, and of the average tracks of storms by months and seasons (Nos. 52 and 53) are of particular value in this connection. The text is well arranged, and presents the main facts in a clear, concise form.

We have but one unfavorable criticism to make. There is no statement in the text as to whether there has been any correction made for the decrease in size of the latitude squares towards the pole in determining the number of storm-centres traced on each five-degree square. Unless this has been done, the numerical results as to average frequency and course of storms are necessarily inaccurate.

TITLES OF RECENT PUBLICATIONS,

FURNISHED BY MR. OLIVER L. FASSIG, LIBRARIAN, U. S. WEATHER BUREAU,
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ELEMENTARY METEOROLOGY.

BY

WILLIAM MORRIS DAVIS,

Professor of Physical Geography in Harvard University.

8vo, Cloth. xii + 355 pages. Price by mail, postpaid, \$2.70.

This work is believed to be opportune, since no elementary work on the subject has been issued in this country for over a quarter of a century. It represents the modern aspects of the science. It is adapted to the use of students in high schools, academies, and colleges, who have already some knowledge of elementary physics, and who wish to gain a general understanding of the processes of the atmosphere. It will meet the needs of members of the National and State Weather Services who wish to acquaint themselves with something more than methods of observation.

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